

# **Control Rod Drive System**

304B Chapter 2.3

# OBJECTIVES

- 1. Identify the purposes of the control rod drive (CRD) system.**
- 2. Recognize the function and operation of the following:**
  - a. Strainers and filters
  - b. CRD pumps
  - c. Reactor recirculation pumps purge and cooling
  - d. Reactor water cleanup (RWCU) pumps purge and cooling
  - e. Flow control station
  - f. Drive water pressure control station
  - g. Charging water header
  - h. Exhaust water header
  - i. Hydraulic control units (HCUs)
  - j. Directional control valves
  - k. Scram valves
  - l. Scram accumulator
  - m. Scram discharge volume

# OBJECTIVES

**3. Recognize the function and operation of the following control rod drive (CRD) mechanism components:**

- a. Outer tube and inner cylinder
- b. Collet assembly
- c. Index tube
- d. Drive piston
- e. Control rod drive coupling device (SPUD)
- f. Piston tube
- g. Position indicating probe

**4. Describe the following flow paths in the CRD system flow:**

- a. Cooling and purge flow
- b. Accumulator charging flow
- c. Withdrawal flow
- d. Insertion flow
- e. Scram flow

# Objectives

- 5. Explain how the control rods are coupled to their CRDM.**
- 6. Explain the differences between a drifting and an uncoupled control rod.**
- 7. Explain how the CRD system interfaces with the following system or components:**
  - a. Condensate and feedwater system
  - b. Condensate transfer and storage system
  - c. Station and instrument air
  - d. Control rods and fuel system
  - e. Reactor manual control system
  - f. Reactor protection system
  - g. Recirculation system
  - h. Reactor water clean up system
  - i. Emergency AC power system

# PURPOSE

- To make changes in core reactivity by positioning control rods in response to the Reactor Manual Control System (RMCS) signals.
- To rapidly insert all control rods to shutdown the reactor in response to the Reactor Protection System (RPS) signals.
- To provide cooling water for the reactor recirculation and reactor water cleanup pump seals.

# Components

- Normal suction source for CRD system is from the condensate system.
  - This provides a source of high quality de-oxygenated water to the CRD pumps
- Suction Filters
  - Remove foreign particulates from the water prior to the CRD pumps.
  - Protects the pump seals, impellers, and other pump internals from excessive wear and damage.
- Suction Strainer
  - The bypass strainer protects the pumps from particles when the suction filters are isolated.

# Components

- CRD pumps
  - Two redundant 200 gpm motor driven centrifugal pumps
  - CRD pumps are cooled by the reactor building closed loop cooling water (RBCLCW) system.
- 20 gpm minimum flow line for each CRD pump
  - The minimum flow line returns water to the CST
  - Prevents pump damage if the system flow is inadvertently stopped
- The pump motors receive power from the 4160V Emergency AC Power System.
  - CRD Pump A from EDG “A” (Bus 101)
  - CRD Pump B from EDG “B” (Bus 102)

# Components

- Drive Water Filters
  - Installed downstream of the CRD pumps
  - Remove particulate prior to CRD system components
- Drive water strainers
  - Installed downstream of the filters
  - Protect the system should a filter fail

# Components

- Reactor Recirculation pump seals
  - cool, clean water CRD water to RR pump seals
  - minimizes the possibility of seal damage by foreign material
- RWCU pump seals
  - cool, clean CRD water to RWCU pump seals
  - minimize seal failure on initial starting of the RWCU system

# Components

- Flow Control Station
  - Measures system flow and transmits it to the flow controller
  - air operated flow control valves (FCVs) maintain system flow at 47 gpm
  - Charging water header is after the flow element, but before the FCV
    - On a scram the FCV closes due to high flow in the charging header
    - Maximizes charging header flow

# Components

- Drive Water Pressure Control Station
  - **Pressure control valve**
    - Manually adjusted motor operated valve
    - Adjusted from the control room to a nominal drive water pressure 260 psig above reactor pressure
    - A manual bypass valve is available if the MOV fails
  - **Stabilizing valve assemblies**
    - Two assemblies consisting of two solenoid operated valves
    - One assembly is in operation the other in standby
    - Stabilizing valve flow bypasses the drive water pressure control valve
    - Stabilizing valves sequence with the directional control valves (DCV's).
      - The stabilizing valve closure coincident with DCV opening maintain a constant drive water pressure

# Components

- **Charging Water header**
  - provides water to the 137 scram accumulators at approx. 1400 psig
  - Orifices in charging header prevent CRD pump run out on a scram
- **Exhaust Water header**
  - Provides a flow path for water exhausted from a mechanism during CRDM movement
    - Water from the moving mechanism exhausts to the other 136
    - The exhaust header pressurizes and DCV 121 for the other 136 mechanisms lift
  - Pressure equalizing relief valves
    - Re-pressurize the exhaust header after a scram.
    - Scram header drains as the DCV 121 valves drain the exhaust header during the initial part of a scram
    - Prevents high differential pressure (high rod speed) in the first rod movements after a scram

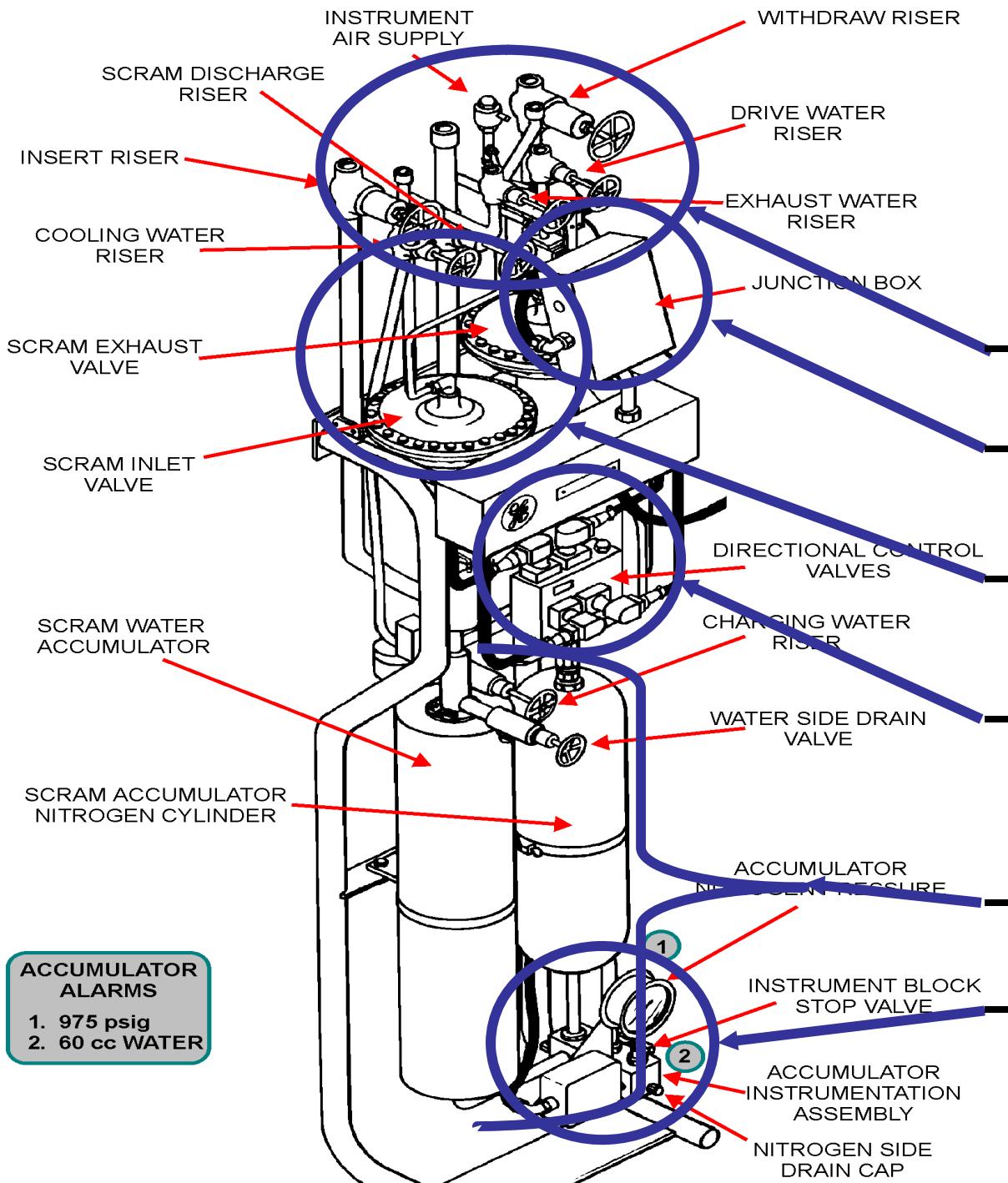
# Components

- Hydraulic Control Units
  - store energy in the accumulators and route that energy through the scram valves
  - route drive water to the directional control valves (DCV's) for normal rod movement
  - route cooling water to the CRDM
- Directional Control valves
  - 4 solenoid valves that control normal rod movement
  - The Reactor Manual Control system provides valve operational signals

# Components

- Scram valves
  - Each HCU has one set of air operated scram valves
  - These position to rapidly insert the control rod
  - Scram valves opened by signals from the RPS system
  - If RPS loses power the scram valves open
- Scram Accumulators
  - Piston water/ $N_2$  accumulator
  - Stores the energy for the initial scram rod movement
  - Alarms in the control room for acc. low  $N_2$  pressure or high water level

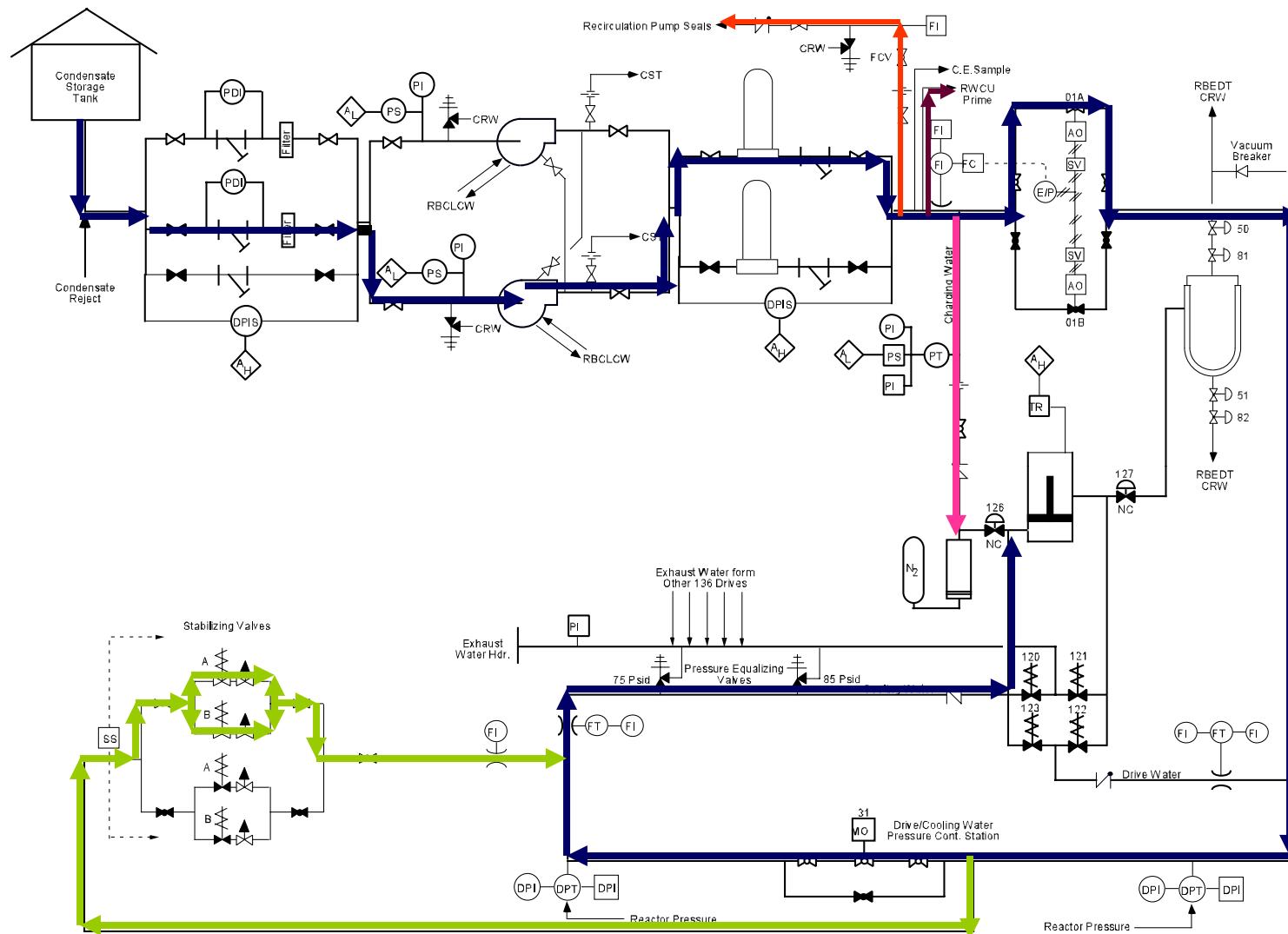
# HCU

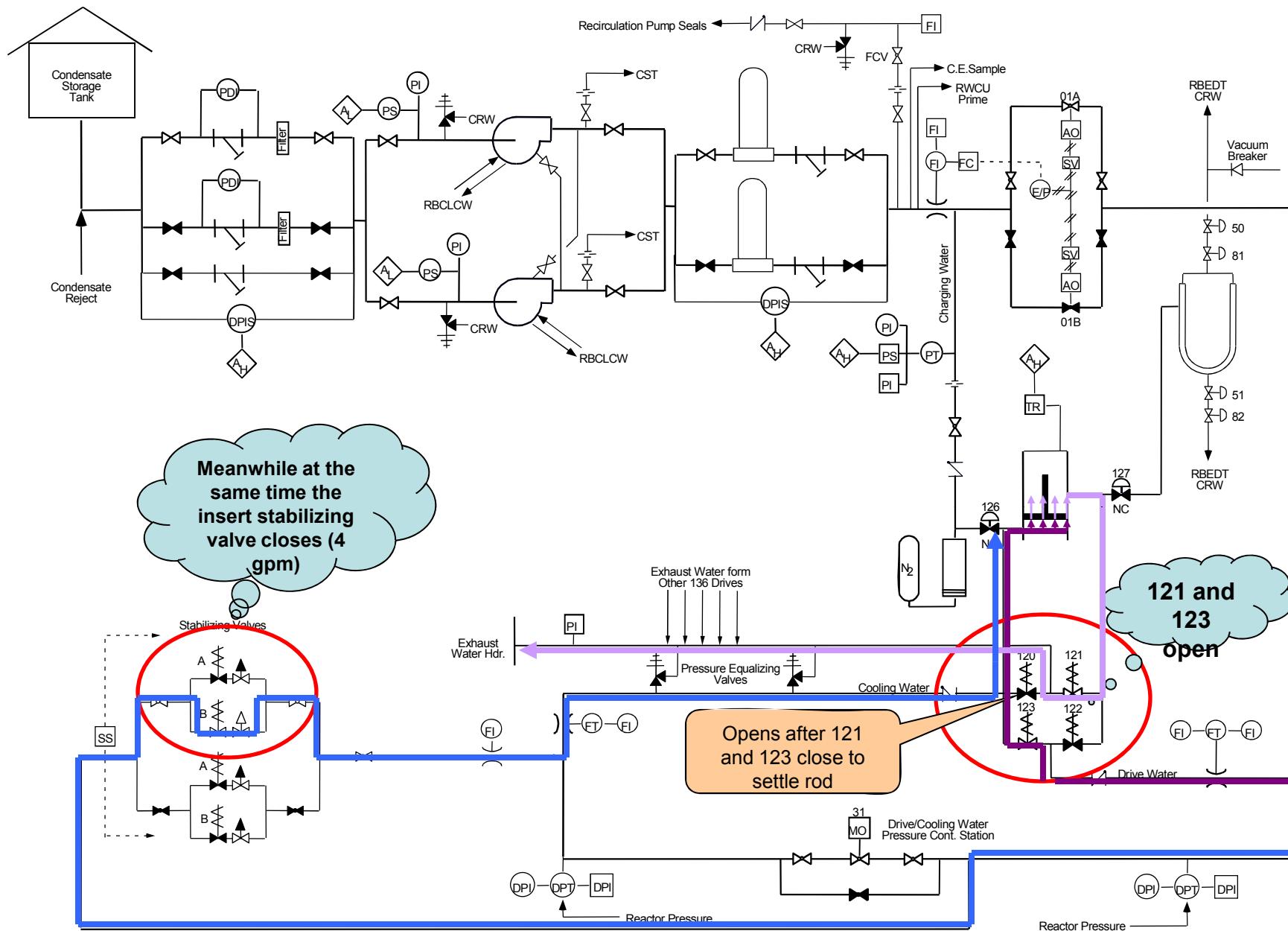


**Riser Isolations**  
**Junction Box**  
**Scram Valves**  
**Directional Control Valves**  
**Accumulator**  
**Instrumentation**

# Components

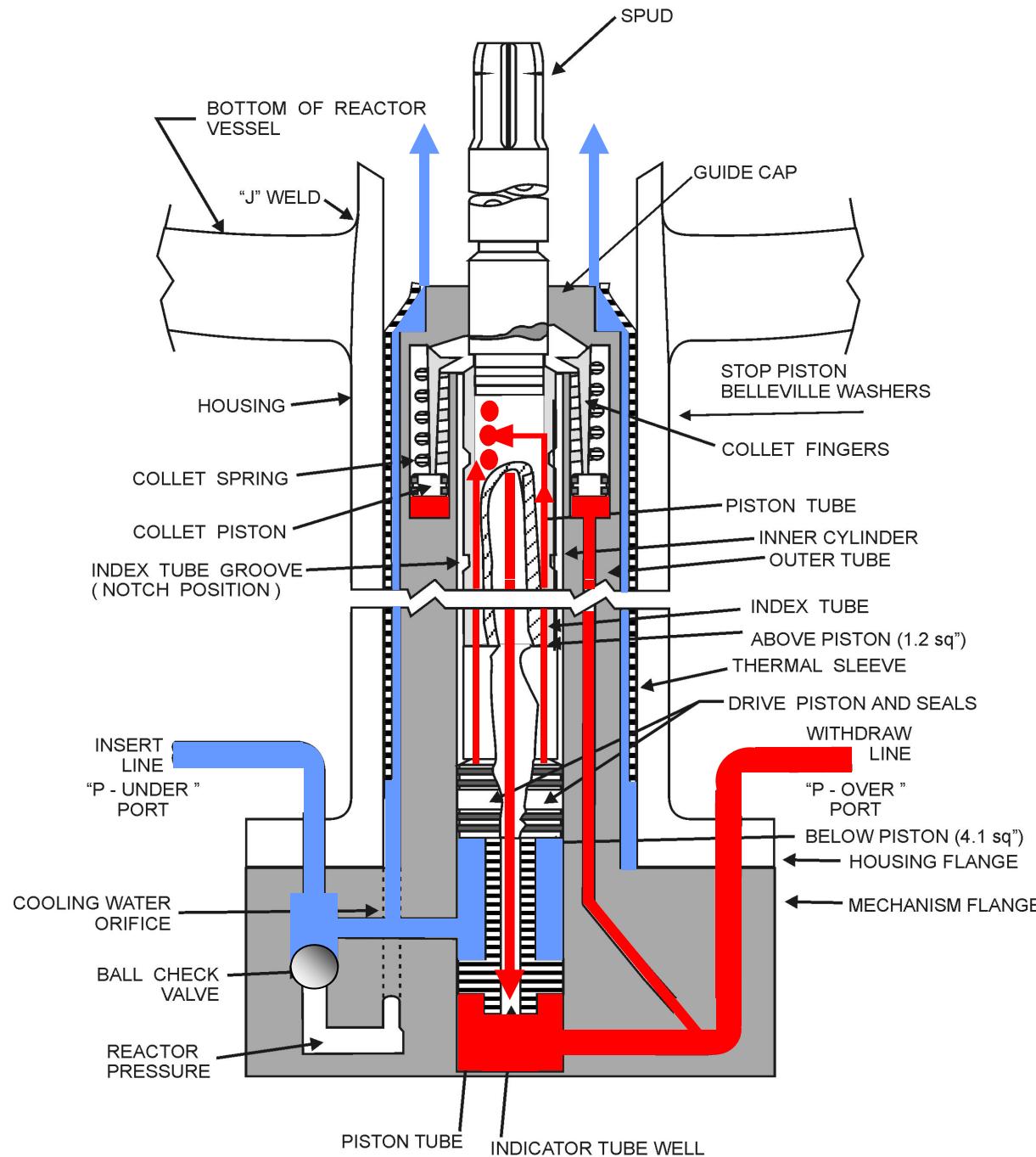
- Scram Discharge Volume (SDV)
  - Receives water from 137 CRD's during a scram
  - Sized to contain twice the required amount of water for a scram
  - Normally open and depressurized to the RBEDT
  - On a scram becomes part of the RPV boundary after the SDV vent and drain valves close.
  - Instrumented to provide rod blocks and scrams if it fills during normal operation

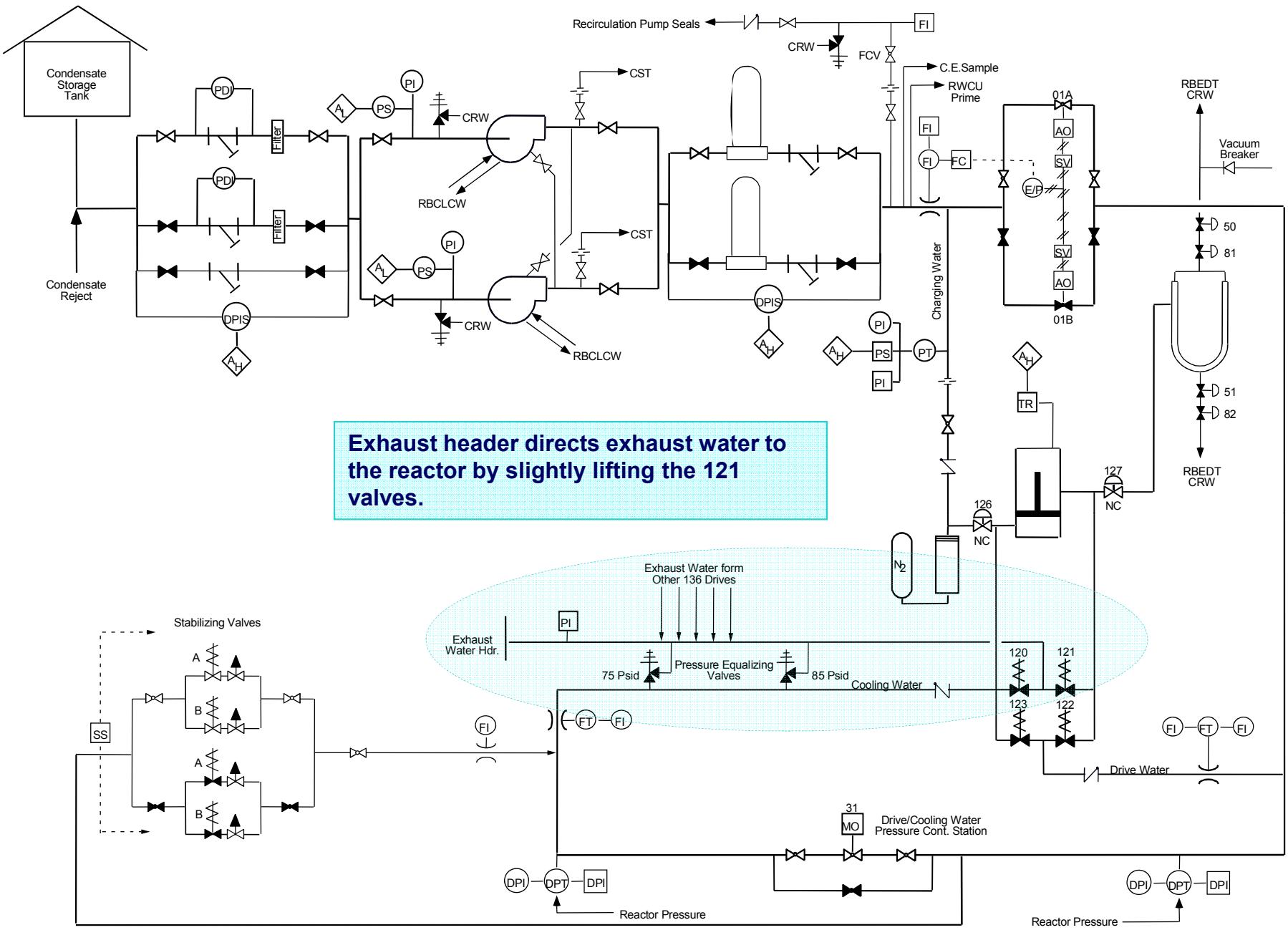


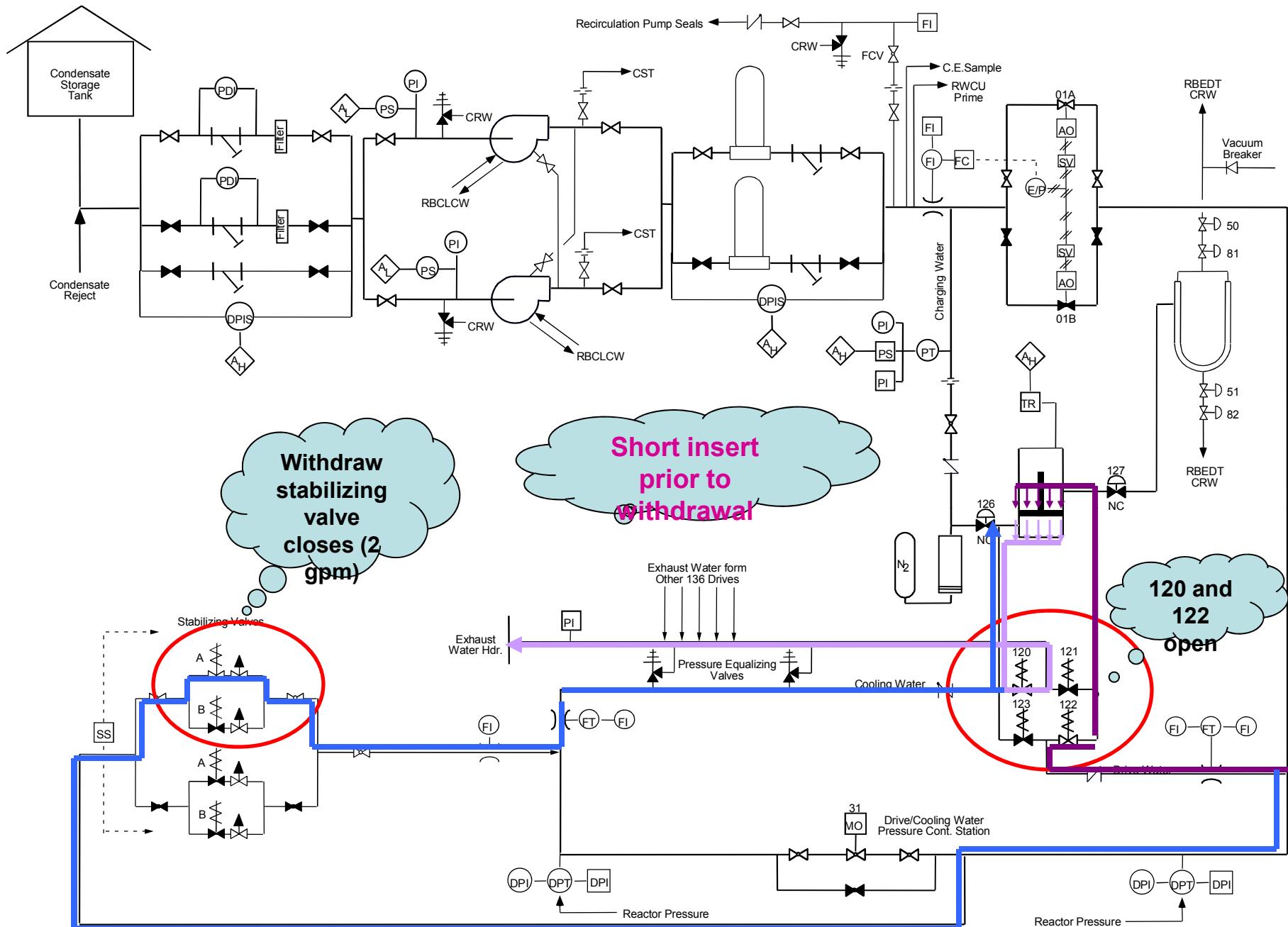


# CRDM FLOWS

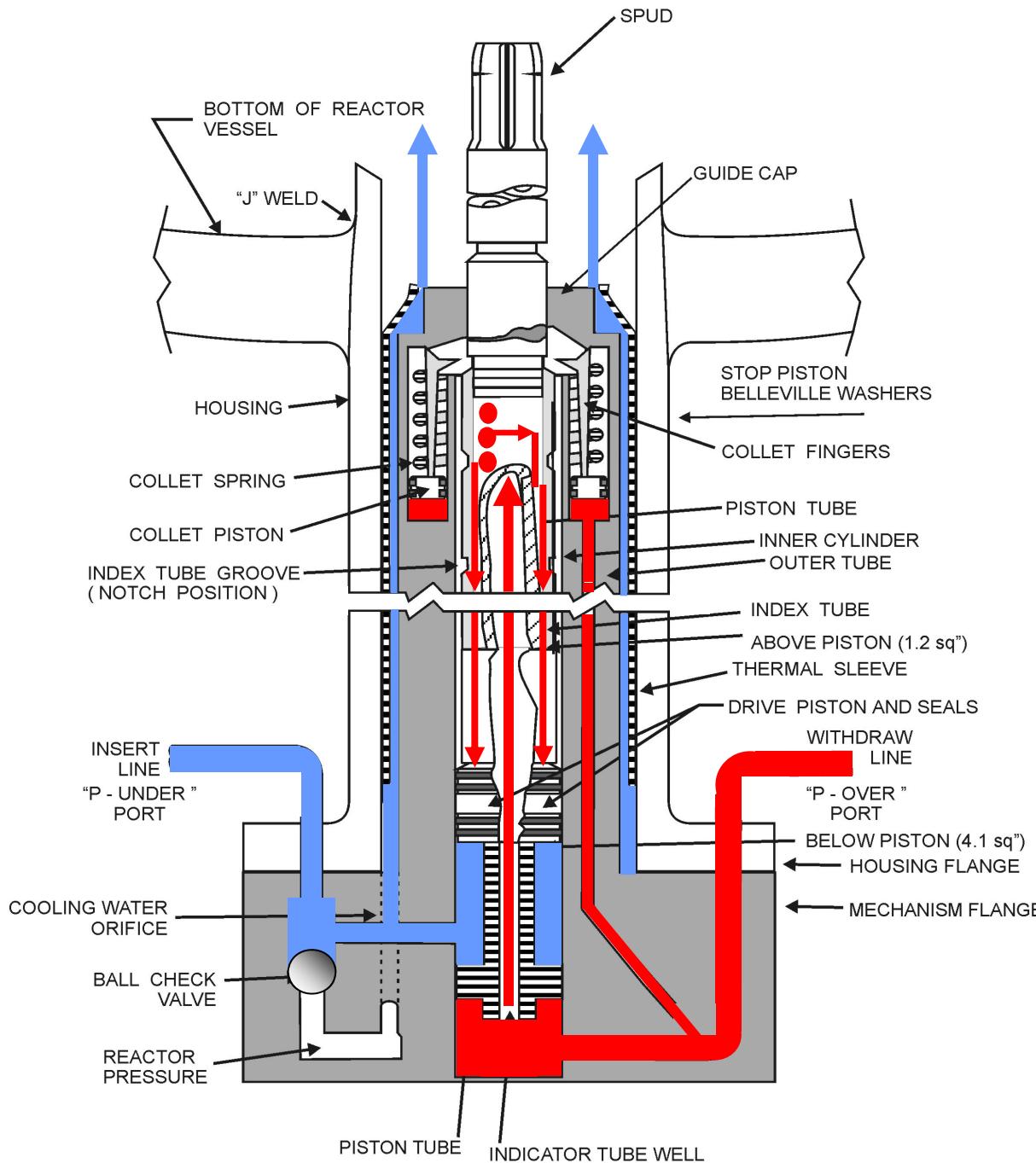
## INSERT





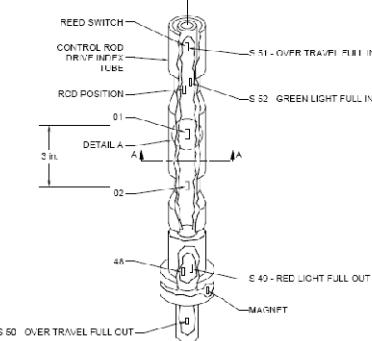


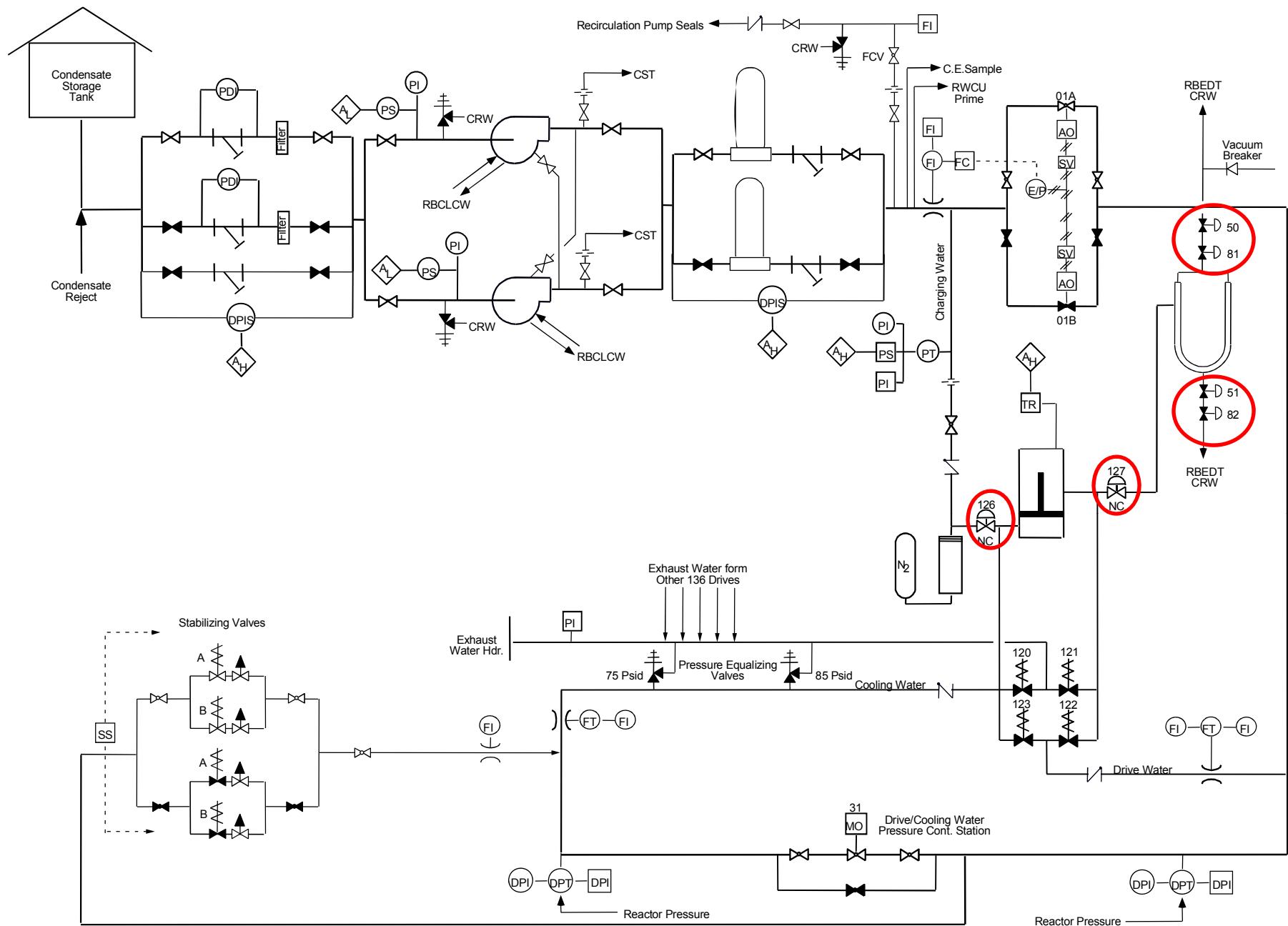
System Withdraw Operation



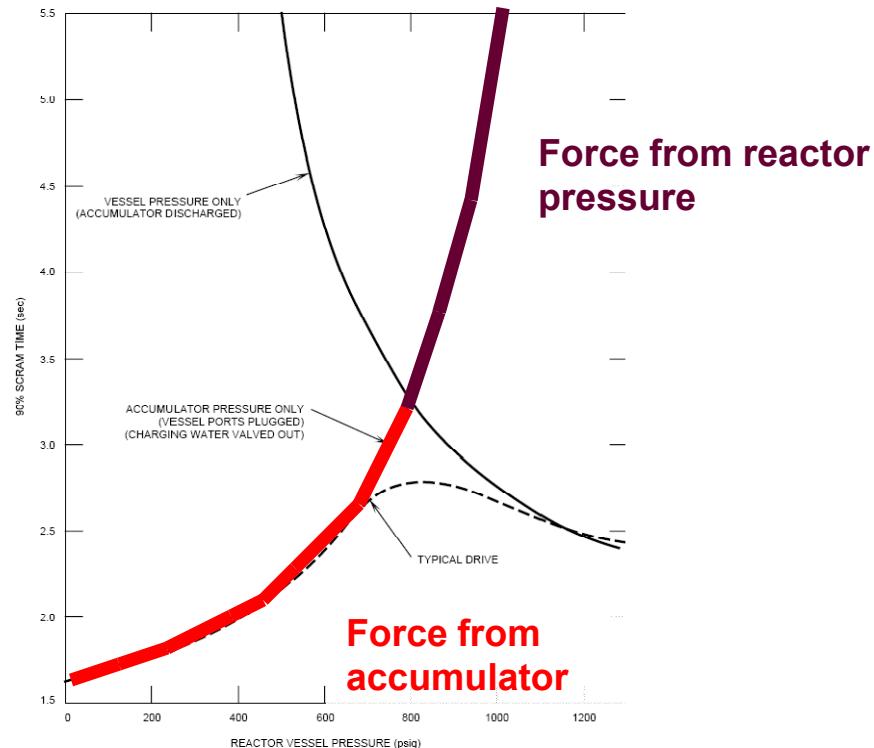
# CRDM FLOWS

## Withdraw



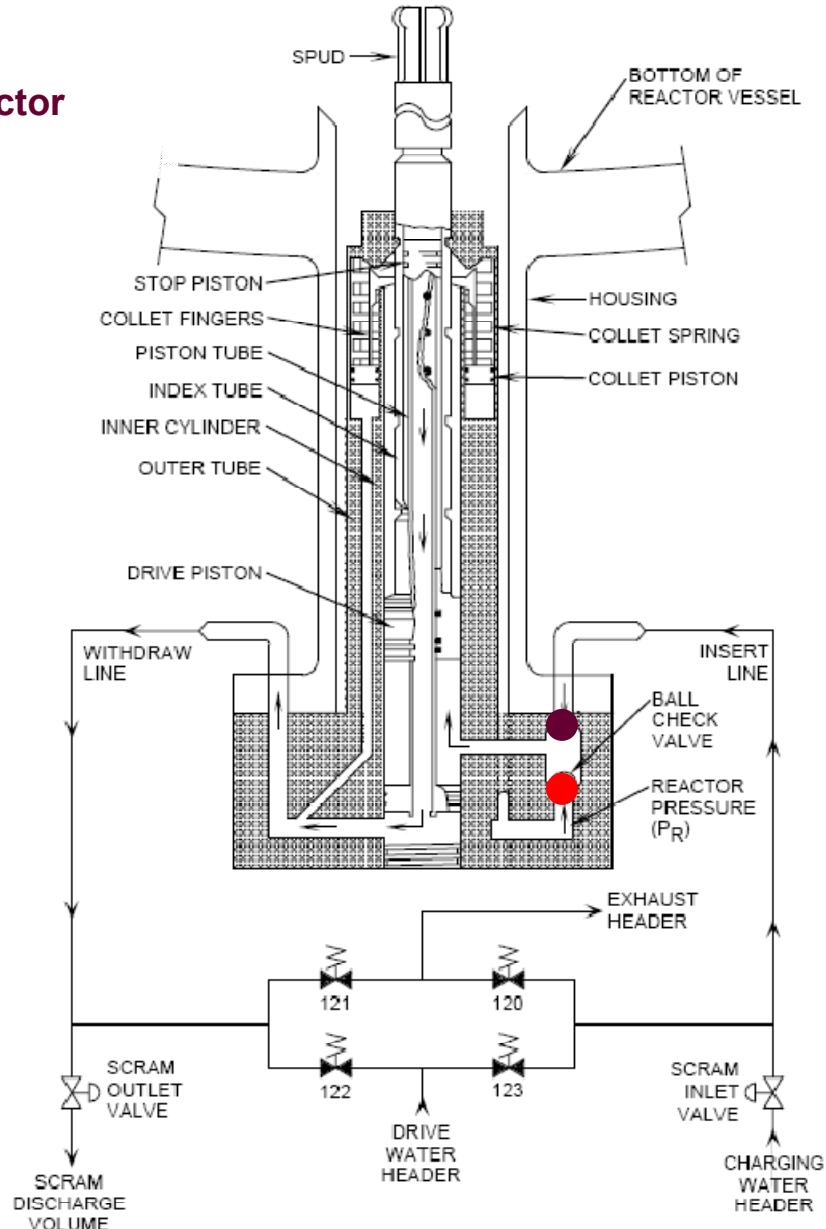


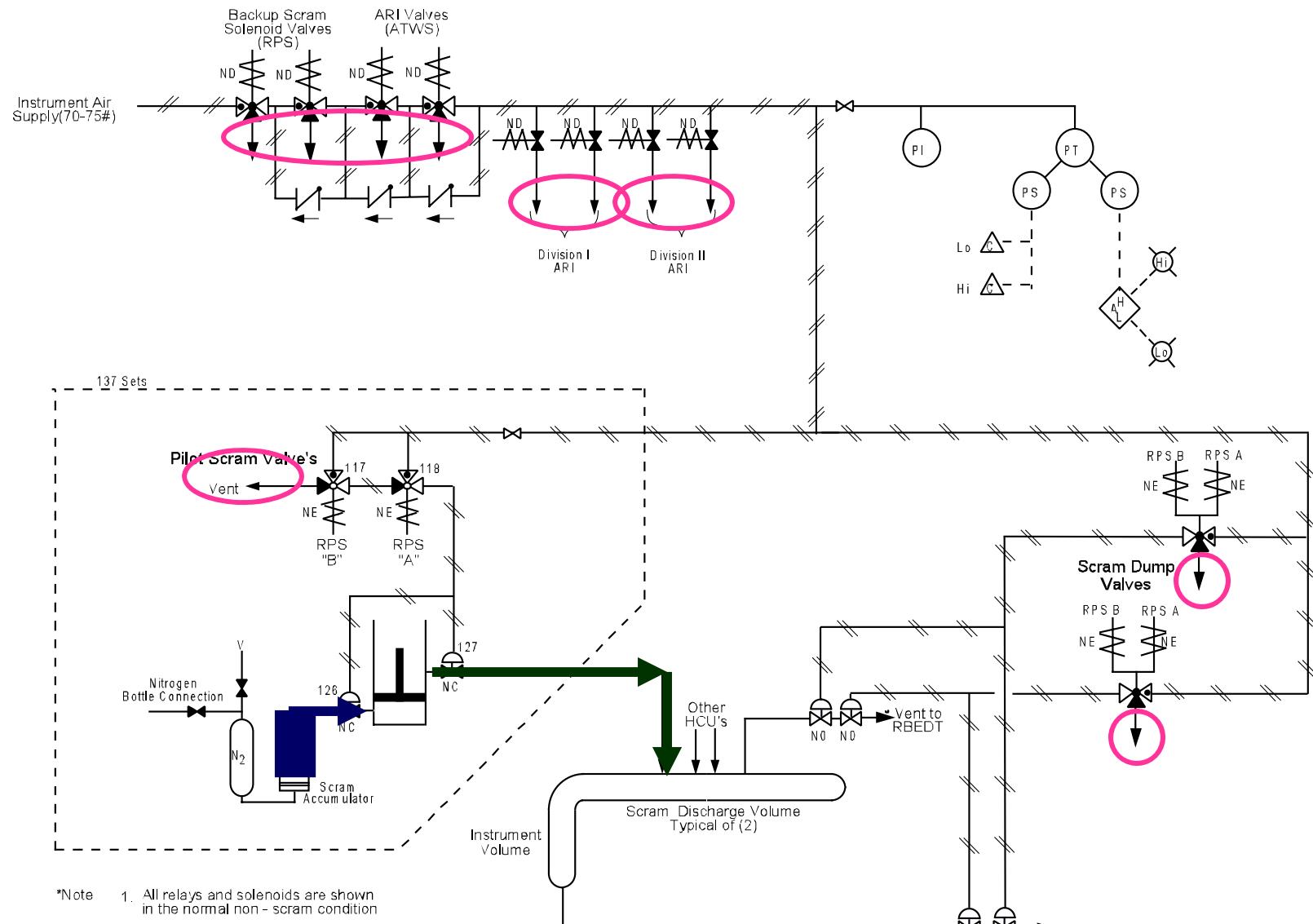
## Reactor Scram



**initial rod motion is provided by pressure in the accumulator.**

**When accumulator pressure lowers below reactor pressure and the ball valve isolates the accumulator from CRDM.**

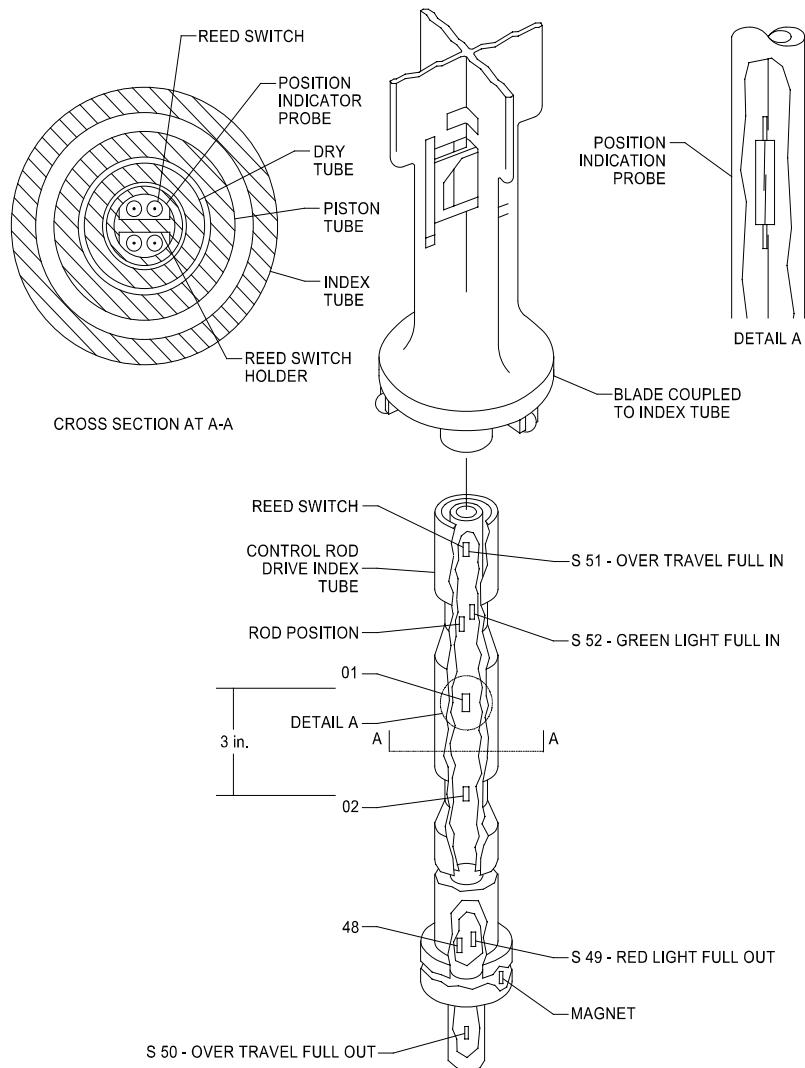




\*Note 1. All relays and solenoids are shown in the normal non - scram condition

2. Three Port Solenoid valves operation (when the solenoid changes state, the dark port opens and the port with the dot closes).

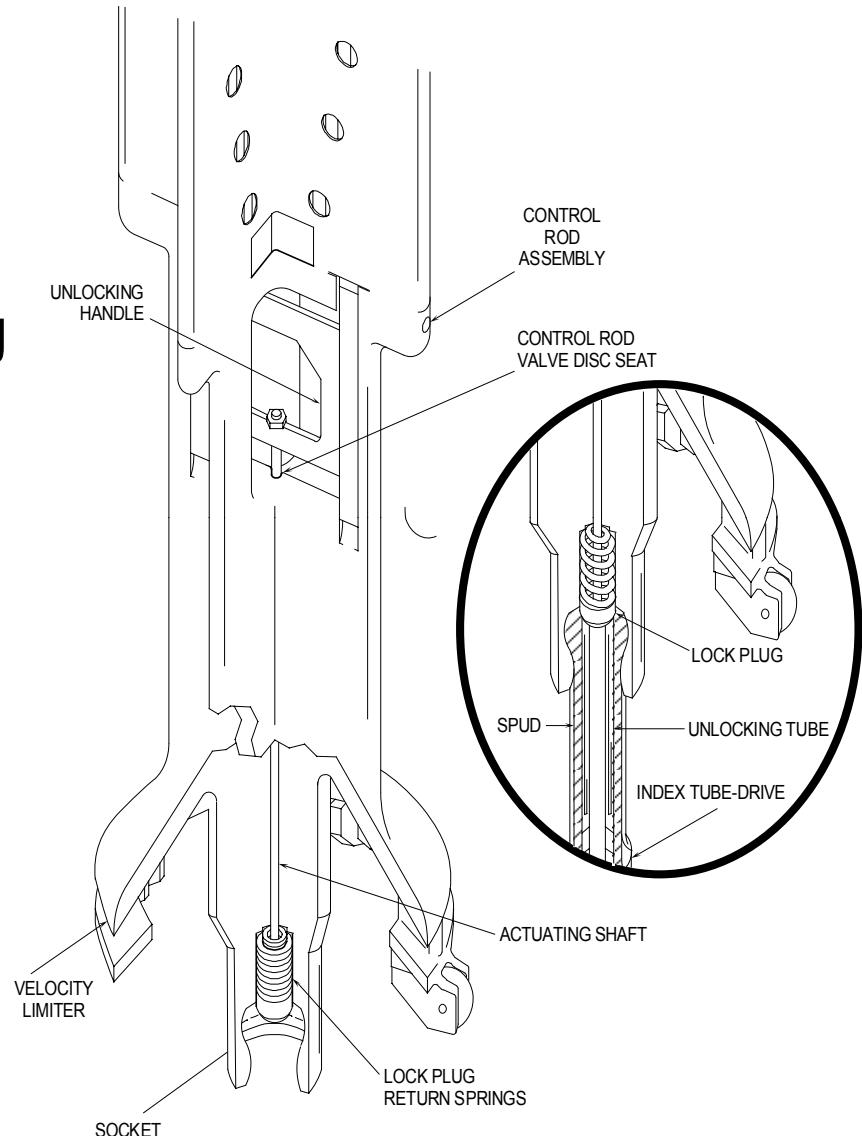
# CRDM Position Indication



- 53 reed switches
  - Even # notches 00-48
  - Odd # notches 01-47
  - Red light full out
  - Green light full in
  - Over travel in
  - Over travel out
- Drive piston magnet activates reed switches
- Position of CRDM not control rod

# CRDM to CR blade coupling

- Coupling “spud”
  - Threaded to upper part of the index tube
  - attaches to the female fitting below the velocity limiter
  - Coupled by weight of the blade against the spud



# Control rod problems

- Drifting Control rod
  - Rod movement without RMCS command
  - Rod drift alarm
- Drift in
  - Leaky scram valve
  - High cooling water pressure
- Drift out
  - Failure of collet assembly to engage
- Uncoupled control rod
  - Mechanism moves out on RMCS commands
  - Blade is not coupled
  - Indicated by rod over travel alarm
- Causes
  - Coupling failure
  - Failure to couple post maintenance
- Rod drop

# System Interfaces

- **Condensate and Feedwater System (Section 2.6)**
  - provides the preferred source of water for the CRD system
- **Condensate Transfer and Storage System (Section 11.6)**
  - provides the backup source of water (CST) for the CRD system
- **Station and Instrument Air System (Section 11.8)**
  - Instrument air supplies the CRD System air operated components.

# System Interfaces

- **Control Rods and Fuel System (Section 2.2)**
  - The control rods are positioned within the reactor core by the CRD System.
- **Reactor Manual Control System (Section 7.1)**
  - Controls the directional control valves and stabilizing valves to control rod movement and drive flow
- **Reactor Protection System (Section 7.3)**
  - Provides signals to open the HCU scram valves, B/U scram valves and close the SDV isolations valves.

# System Interfaces

- **Recirculation System (Section 2.4)**
  - Receives cool, clean water from the CRD System for recirculation pump seal purge.
- **Reactor Water Cleanup System (Section 2.8)**
  - Receives cool, clean water from the CRD system for the reactor water cleanup pump seals for initial system startup.
- **Emergency AC Power System (Section 9.2)**
  - Supplies power to the CRD pumps A and B.

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